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A SOLAR CELL WITH AN INTEGRATED BATTERY CHARGING FUNCTION
[Chikuden kinoo wo ittaika shita taiyoo denchi]

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Specification

1. Title of the invention

A solar cell with an integrated battery charging function

2. Scope of patent claims

1. A solar cell with an integrated battery charging function comprising a solar cell that is covered by an electrically insulating film and that is comprised of a first electrode, a thin film semiconductor layer and a second electrode that are formed on top of a translucent substrate, and in which a third electrode that is electrically connected to either the first electrode or the second electrode, a dielectric film, and a fourth electrode that is electrically connected to either the first electrode or the second electrode, whichever is remaining, have been formed, in this sequence.

2. The solar cell with an integrated battery charging function as noted in Claim 1 of the Scope of Patent Claims in which the solar cell that is comprised of the first electrode, thin film semiconductor layer and second electrode that were formed on top of the translucent substrate includes a single photovoltaic element.

3. The solar cell with an integrated battery charging function as noted in Claim 1 of the Scope of Patent Claims in which the solar cell that is comprised of the first electrode, thin film semiconductor layer and second electrode that were formed on top of the translucent substrate includes 2 or more photovoltaic elements that are connected in series.

4. The solar cell with an integrated battery charging function as noted in Claim 1 of the Scope of Patent Claims in which a protective film is formed after the formation of the fourth electrode.

3. <u>Detailed explanation of the invention</u>

(Field of industrial application)

The present invention relates to a solar cell with an integrated battery charging function.

(Prior art)

Solar cells will not generate power if there is no light, and therefore, cannot be used as batteries in dark locations. Therefore, solar cells are used in combination with secondary batteries.

(Problem to be solved by the invention)

However, because of the structural restrictions on secondary batteries that have already been disclosed, it is

not possible to thin or lighten these secondary batteries.

Also, because solar cells do not have sufficient capacity to act as the power source to charge secondary batteries, it is not possible to completely recover the discharge current of a secondary battery, leading to problems in terms of product life.

The present invention was created in order to solve the afore-mentioned problems with conventional solar cells.

(Means for solving the problem)

The present invention was created based on the discovery that, by forming both a solar cell and condenser on top of the same substrate, it is possible to solve the problems that arise when using a solar cell and secondary battery in combination. The present invention relates to a solar cell with an integrated battery charging function comprising a solar cell that is covered by an electrically insulating film and that is comprised of a first electrode, a thin film semiconductor layer and a second electrode that are formed on top of a translucent substrate, and in which a third electrode that is electrically connected to either the first electrode or the second electrode, a dielectric film, and a fourth electrode that is electrically connected

to either the first electrode or the second electrode, whichever is remaining, have been formed, in this sequence.

(Examples of embodiment)

Examples of translucent substrates that can be used as the translucent substrate in the present invention include translucent substrates that are commonly used in solar cells, such as substrates made from glass, ceramic, or polymeric substances, and there are no particular restrictions on the material that can be used.

For the first electrode to be used in the present invention, it is possible to use a transparent electrode made of ITO, SnO_2, ITO/SnO_2 or the like, or a material that is constructed with or such that it may accept a thin silicide layer on the thin film semiconductor layer side of said translucent electrode, but the first electrode is not limited to these materials.

While there are no particular restrictions on the thickness of the first electrode, it is generally preferable to use a material with a thickness of approximately 700 to 10000 Å, and it is even more preferable to use a material with a thickness of 700 to 6000 Å. As shown in Figure 1, the first electrode (2) in the present invention may be formed to have a pattern such

that it is possible to form a serial connection if necessary.

For the thin film semiconductor to be used in the present invention, it is acceptable to use a material that has a Group II-VI pn junction, a material that has a non-single crystal pin junction or pn junction including at least one type of element such as Si, Ge, C, or Sn, a multi-junction type material in which these junctions are repeated, or a pin multi-junction type material including a diffusion blocking layer (such as a silicide layer) on the pn surface boundary, but the thin film semiconductor is not limited to these examples.

In the present invention, the thin film semiconductor (3) is formed after the formation of the first electrode (2).

While there are no particular restrictions on the thickness of the thin film semiconductor, in general, when using a material with a Group II-VI pn junction, it is preferable to have a thickness of approximately 1 to 100 μm, and it is even more preferable to have a thickness of approximately 2 to 50 μm. Also, when using a material with a non-single crystal pin junction or pn junction that includes at least one element such as Si or the like, it is preferable to have a thickness of approximately 0.2 to 500

μm, and it is even more preferable to have a thickness of 0.5 to 200 μm. When using a multi-junction type material in which these junctions are repeated, it is preferable to have 2 to 4 repetitions of a material with a thickness of approximately 0.1 to 2 μm. Similarly, when using a pin multi-junction type material including a diffusion blocking layer on the pn surface boundary, it is preferable to have 2 to 4 repetitions of materials with thicknesses of approximately 0.1 to 2 μm.

Specific examples of the afore-mentioned materials with Group II-VI pn junctions include, for instance, CdS and CdTe. Also, specific examples of materials with a non-single crystal pin junction or pn junction that include at least 1 element such as Si or the like are, for instance, p-type amorphous silicon carbide/i-type amorphous silicon/n-type microcrystalline silicon components that are constructed using materials such as amorphous silicon, microcrystalline silicon, polycrystalline silicon, amorphous silicon carbide, amorphous silicon nitride, amorphous silicon germanium, and amorphous silicon tin. Specific examples of multi-junction type materials that comprise a repetition of these junctions include, for instance, p-type amorphous silicon carbide/i-type amorphous silicon/n-type amorphous silicon/p-type amorphous silicon

carbide/i-type amorphous silicon germanium/n-type amorphous silicon components that are constructed using the same materials as noted above. Further, an example of a pin multi-junction type material that includes a diffusion blocking layer on the pn surface boundary is a material in which, in addition to the structure of the afore-mentioned multi-junction type material, there is a structure in which a metallic layer with a thickness of 10 to 40 Å and various silicide layers have been introduced between the n-type amorphous silicon/p-type amorphous silicon carbide components.

The following explanation will mainly focus on the solar cell according to the present invention which is comprised of the sequential formation of a third electrode that is electrically connected to the first electrode, a dielectric film, and a fourth electrode that is electrically connected to the second electrode.

As described above, after the sequential formation of the first electrode (2) and thin film semiconductor layer (3) on top of the translucent substrate (1), the second electrode (4) will be formed to form the solar cell to be used in the present invention.

The said solar cell may be a solar cell that includes a single photovoltaic element, or it may be a solar cell in which 2 or more, or more preferably, 2 to 30, photovoltaic elements are connected in series. It may also be a solar cell that includes 2 or more photovoltaic elements that are connected in parallel.

For the afore-mentioned second electrode, it is acceptable to use, for instance, a transparent electrode with a thickness of approximately 1000 to 50000 Å and a metallic layer that is formed of Al, Ag, Cr, Cu or the like, and after creating a diffusion blocking layer such as silicide on top of the thin film semiconductor layer or by forming a diffusion blocking layer, it is preferable to form a metallic layer of Ag, Al, Cu or the like for use as the second electrode.

In the event that 2 or more photovoltaic elements are to be connected in series, the formation of the second electrode (4) such that it will be connected in series with the adjacent first electrode (2), as shown in Figure 1, will improve the production properties, and this structure is also preferable from the standpoint of ensuring the voltage required in charging and the required operating voltage.

An electrically insulating film (5) is formed such that it encloses the translucent substrate (1) for the solar cell that is prepared in this manner, the opposite side translucent substrate of the solar cell, and the entire area other than the discharge electrode areas (2a) and (4a) of the first electrode and second electrode. Further, on top of this electrically insulating film (5), a third electrode (6) is formed such that it will be electrically connected to the discharge electrode area (2a) of the first electrode and such that it will not be connected to the discharge electrode area (4a) of the second electrode.

The said electrically insulating film is a film with a thickness of approximately 1 to 500 μm or more preferably, with a thickness of approximately 2 to 100 μm, that is formed of a material that has a specific resistance of approximately 10^{12} Ω cm or more, and it will act to insulate the third electrode from the area other than the discharge electrode part of the first electrode in the solar cell.

For the material to form the said electrically insulating film, it is acceptable to use, for instance, an organic insulating material that is applied using the glow discharge method or coating method, an inorganic insulting material that is formed using the deposition method or

sputtering method, or an amorphous insulating material such as a-SiC:H, a-SiN:H, a-SiO:H, a-SiCN:H, a-SiNO:H, a-SiC:F, a-SiN:F, a-SiO:F, a-SiCN:F, a-SiNO:F, a-SiC:H:F, a-SiN:H:F, a-SiO:H:F, a-SiCN:H:F, or a-SiNO:H:F that is formed using the glow discharge method or sputtering method.

As long as the third electrode is a material with a thickness of approximately 1000 to 50000 Å that is formed from a metallic layer or from the transparent electrode that forms the first electrode or second electrode, there are no particular restrictions on the use of this component.

Similarly, there are no particular restrictions on the shape or on the areas to be created for the third electrode, and the third electrode may be formed in any manner as long as the afore-mentioned conditions are satisfied, but it is common to form the third electrode as shown in Figure 2 (an explanatory diagram for the (A)-(A) cross-section of Figure 1).

The dielectric film (7) to be used in the present invention is formed on top of the third electrode (6) and, as necessary, on top of the electrically insulating film (5) such that it will not cover the discharge electrode areas (2a) and (4a) of the first electrode and the second electrode. Further, on top of this, the fourth electrode (8) is formed such that it will be electrically connected

to the discharge electrode area (4a) of the second electrode and such that it will not be connected to the first electrode.

There are no particular restrictions on the material to form the said dielectric film, but it is preferable to use a material with a low Tan δ and with a large ε value.

The dielectric film that uses this type of material may be formed using a polymeric substance such as

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polycarbonate, polysulfone, polyethylene, or polypropylene using a coating method or glow discharge decomposition method, it may be formed using the Langmuir-Blodgett (hereinafter abbreviated as LB) method as an LB film from a compound that can be formed into a film, it may be formed using an inorganic substance such as TiO_2, $TiBaO_4$, $TiSrO_3$ or PLZT using a sputtering method or glow discharge method, or it may be formed using an amorphous substance containing a-SiC, a-SiN, a-SiO, a-SiCN, a-SiNO or the like, or using substances such as these that also contain H or F and using a sputtering method or glow discharge method to form a film. Of these, it is preferable to have a dielectric film that is formed using polycarbonate, polysulfone, an LB film, TiO2, TiBaO4, TiSrO3, a-SiC, a-SiN, or a-SiC or a-SiN that also contain H or F.

As long as there are no defects in the film and there is no destruction of the insulating properties, it is preferable that the thickness of the said dielectric film is as small as possible in order to increase the capacity of the condenser, and it is preferable for the thickness to be 10 µm or less, though it is even more preferable for the thickness to be 3 µm or less.

Normally, the dielectric film will be formed as shown in Figure 2, but as long as it is formed such that it separates the third electrode and the fourth electrode, there are no particular restrictions on the shape or on the position of the film.

There are no particular restrictions on the thickness or other properties of the material for the fourth electrode, and it may be the same as was used in the third electrode.

Similarly, there are no restrictions on the area or shape of the fourth electrode as long as the aforementioned conditions are satisfied, but in order to form a condenser as well as the third electrode and dielectric film, it is preferable to form the fourth electrode such that it faces the third electrode via the dielectric film.

In the above explanation, the explanation was mainly based on Figure 1, in which 4 solar cell elements are

connected in series, but it is also acceptable to have a product in which there is a single solar cell element, or to have an integrated solar cell element such as a multi-junction type material. Figure 3 is a diagram to explain the equivalence circuit into which the condenser (10) is built in parallel to the serial connection of the 4 photovoltaic elements (9).

Next, we will explain the preferred example of embodiment of the solar cell according to the present invention.

A first electrode, which is a transparent electrode with a thickness of approximately 700 to 5000 Å, is formed as a pattern if necessary on top of a glass or ceramic translucent substrate with a thickness of approximately 0.7 to 2 mm, and then, when for instance, the first electrode has been formed as a pattern, as shown in Figure 1, a thin film semiconductor layer with a thickness of approximately 0.5 to 2 μm and that is composed of amorphous silicon carbide or amorphous silicon is formed. Further, a second electrode is formed of silicide or Al with a total thickness of approximately 2000 to 30000 Å. An electrically insulating film with a thickness of approximately 2 to 10 μm and that is formed of a-SiC:H is created such that it will not cover the translucent substrate part, the

discharge electrode part of the first electrode, or the discharge electrode part of the second electrode of the solar cell that has been prepared in this manner.

Further, on top of this electrically insulating film, a third electrode with a thickness of approximately 2000 to 30000 Å and that is formed of Ni, Cr, or Al is created such that it will be electrically connected to the discharge electrode part of the first electrode. Then, a dielectric layer of TiBaO4 with a thickness of approximately 2 to 3 µm is formed on the areas excluding the translucent substrate, the discharge electrode area of the first electrode and the discharge electrode area of the second electrode, and next, a fourth electrode of Ni, Cr or Al with a thickness of 2000 to 30000 Å is formed such that it will be electrically connected to the discharge electrode area of the second electrode.

If necessary, after the formation of the fourth electrode, it is acceptable to use an epoxy resin or the like to form a protective film with a thickness of approximately 5 to 200 µm.

The above explanation is focused on the case in which a third electrode that is electrically connected to the first electrode, a dielectric film, and a fourth electrode that is electrically connected to the second electrode have

been formed in this sequence, but it is possible to provide a similar explanation for the case in which a third electrode that is electrically connected to the second electrode, a dielectric film, and a fourth electrode that is electrically connected to the first electrode have been formed in this sequence.

Because the solar cell according to the present invention that has been manufactured in this way has an integrated battery charging function, when light is shining, the solar cell will work to charge the condenser, but even

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when there is no light, it will be possible to use the solar cell as a battery until the condenser is discharged.

The solar cell according to the present invention that has been manufactured in this manner can be optimally used as the power source for electronic devices such as clocks, calculators, games, musical greeting cards, toys, or radios.

(Effect of the invention)

The solar cell with an integrated battery charging function according to the present invention is simply a material in which an electrically insulating film, two electrodes (a third and a fourth electrode) and a dielectric film have been added to a solar cell, and these additions will have almost no effect on the size of the

solar cell. Also, because a dielectric material is used in lieu of the conventional secondary battery, it is possible to integrate this material, ensuring low cost and a compact design.

4. Brief explanation of the drawings

Figure 1 is an explanatory diagram relating to the cross-section of one example of embodiment of the solar cell according to the present invention. Figure 2 is an explanatory diagram relating to the (A)-(A) cross-section of the solar cell according to the present invention as shown in Figure 1. Figure 3 is an explanatory diagram relating to the equivalence circuit into which the condenser is built in parallel to the solar cell in which 4 photovoltaic units have been connected in series.

(Explanation of the references)

(1): Translucent substrate

(2): First electrode

(3): Thin film semiconductor layer

(4): Second electrode

(5): Electrically insulating film

(6): Third electrode

(7): Dielectric film

(8): Fourth electrode

Figure 1

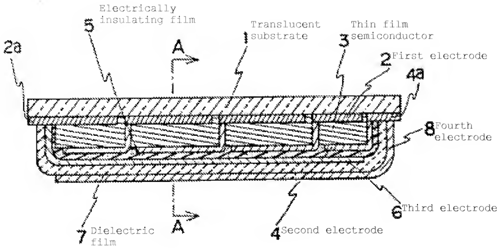


Figure 2

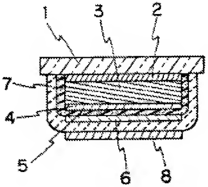
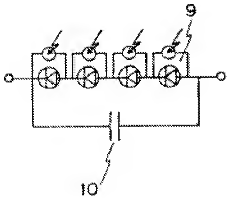


Figure 3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